BTeV Detector Elements and Front End Electronics (a quick review)

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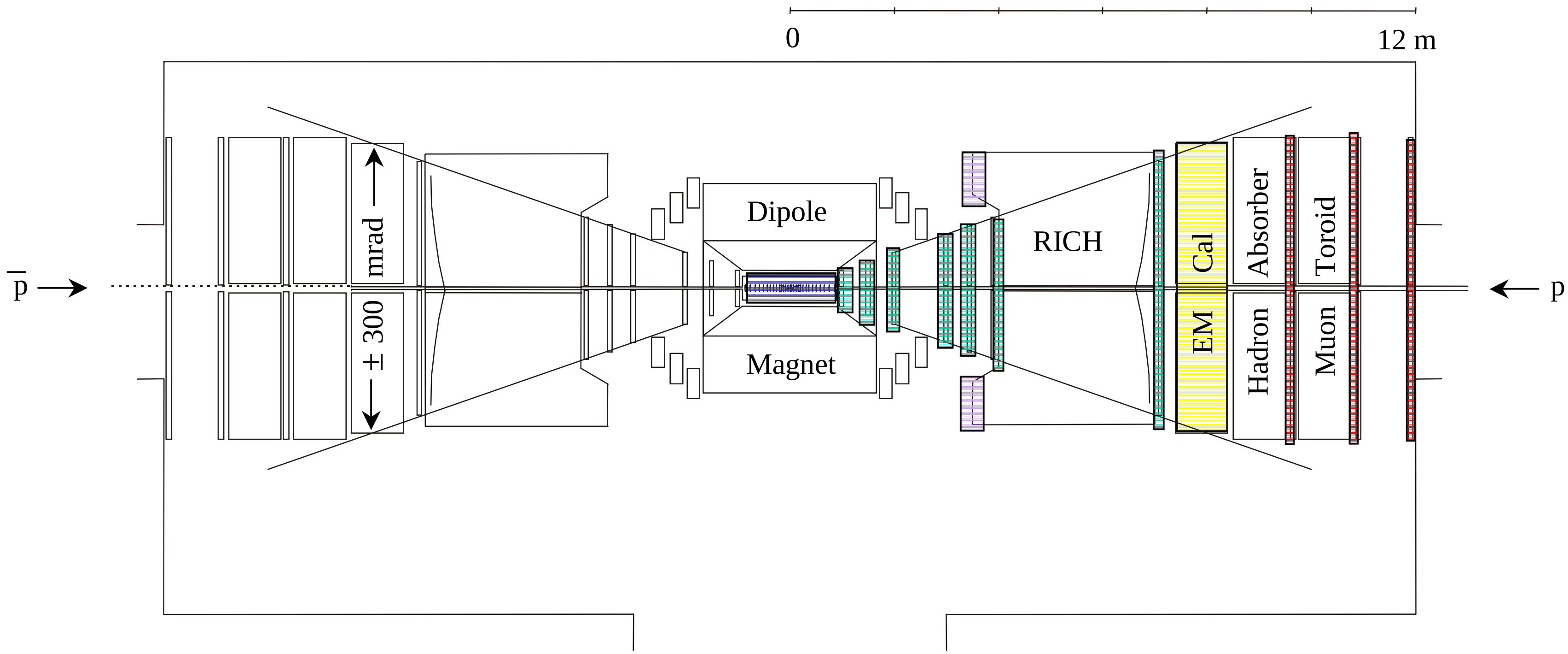
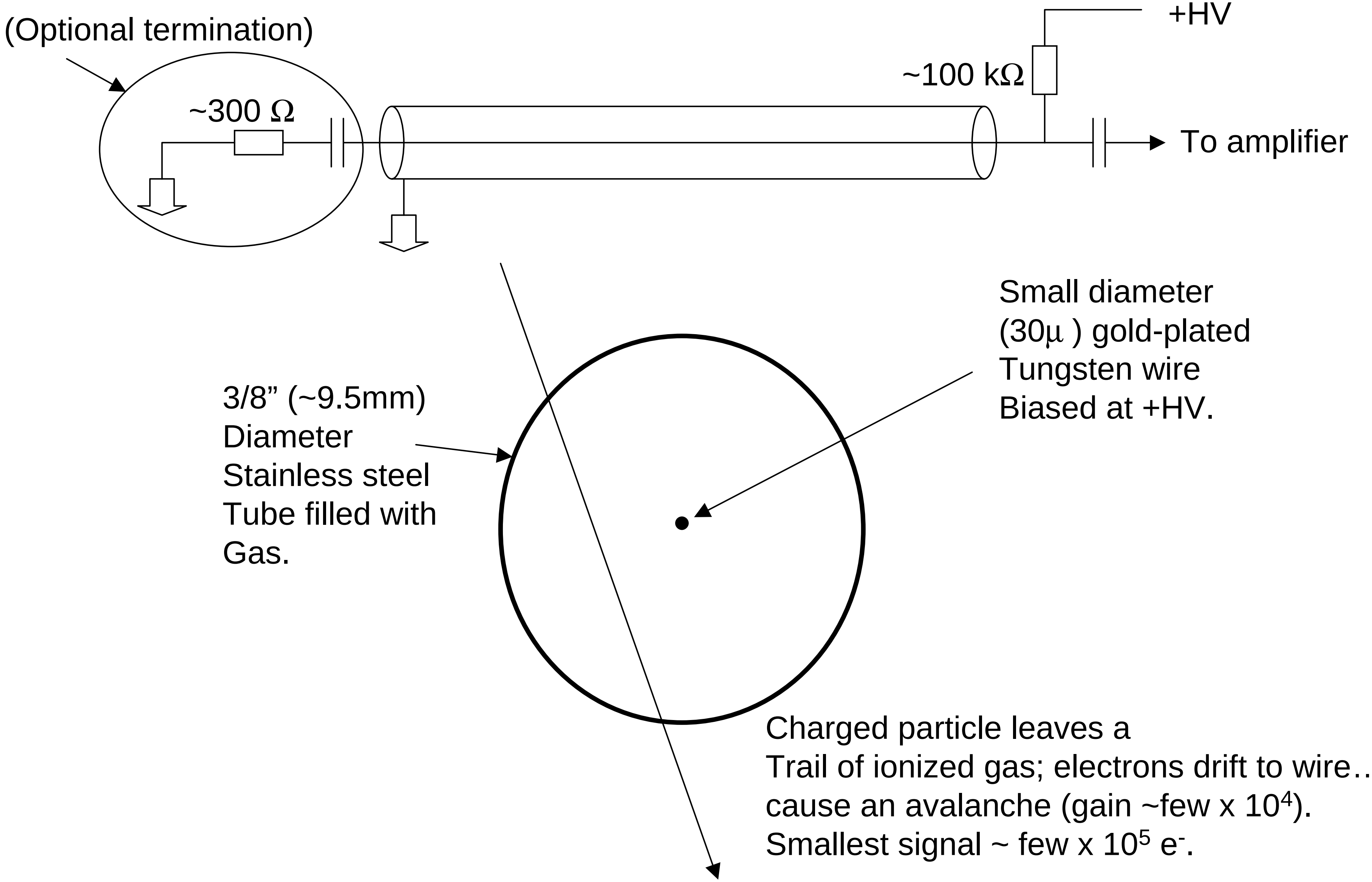
November 2, 2000

The BTeV Detectors



- Silicon pixels
- Forward tracker = straw chambers and silicon strip detectors
- Muon chambers
- RICH photo detectors
- Electromagnetic calorimeter

Cross Section of a Muon Tube



Charged particle leaves a
Trail of ionized gas; electrons drift to wire…
cause an avalanche (gain ~few x 10^4).
Smallest signal ~ few x 10^5 e^-.

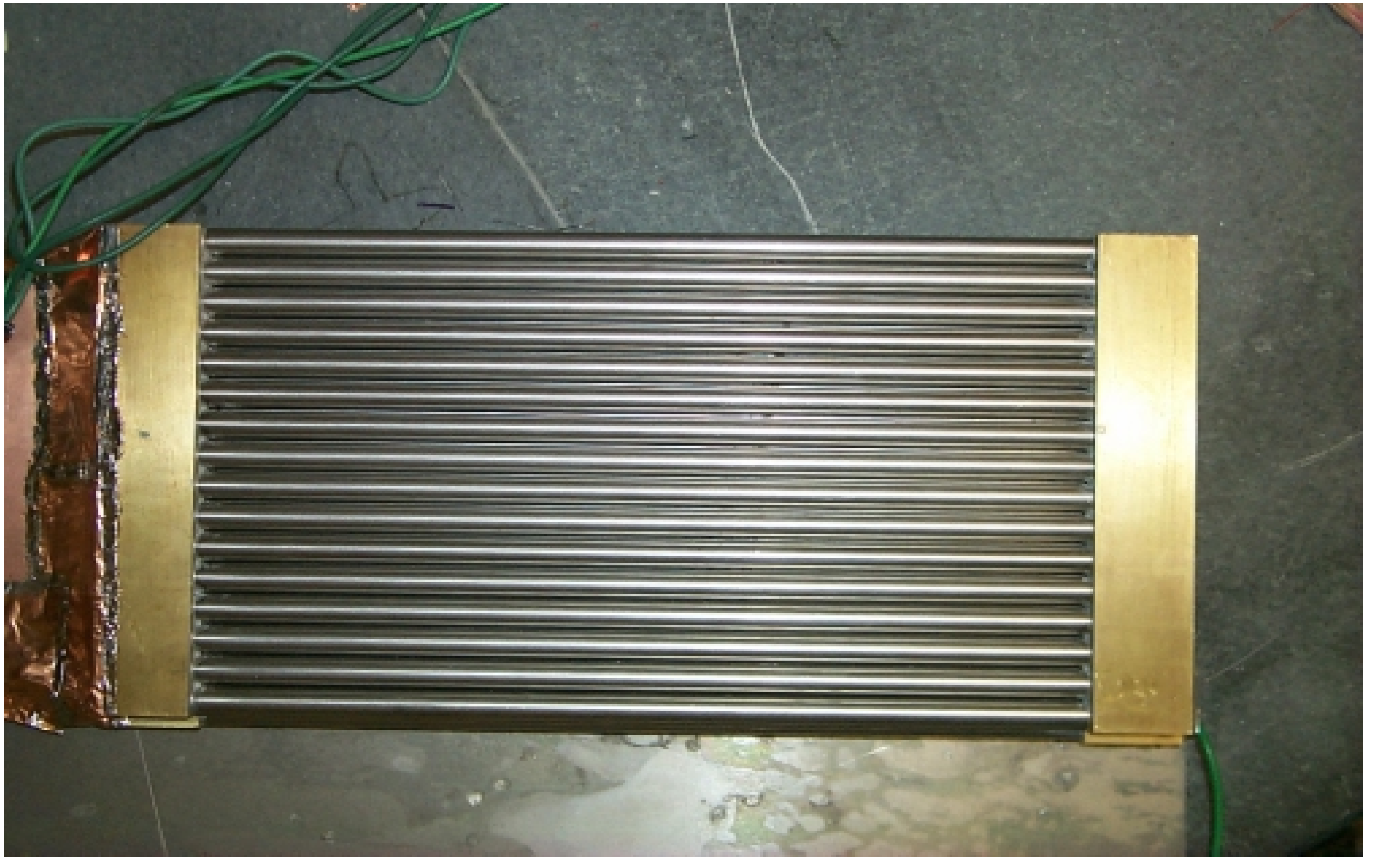
Muon chambers: ~80K channels

Front-end = U. Penn. ASD (ASDQ designed for CDF COT)
“**A**mplifier **S**haper **D**iscriminator”

Latch/zero suppression/r/o not yet defined? --- proposal says serialization is at the octant level.

http://www.hep.vanderbilt.edu/~wjohns/res/btev/proto2/index.html

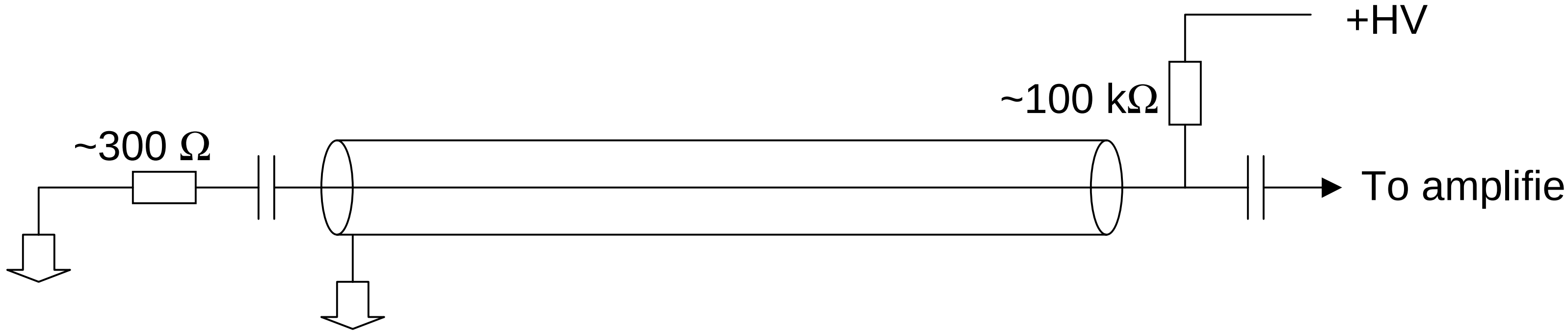
A close up of prototype muon tubes.



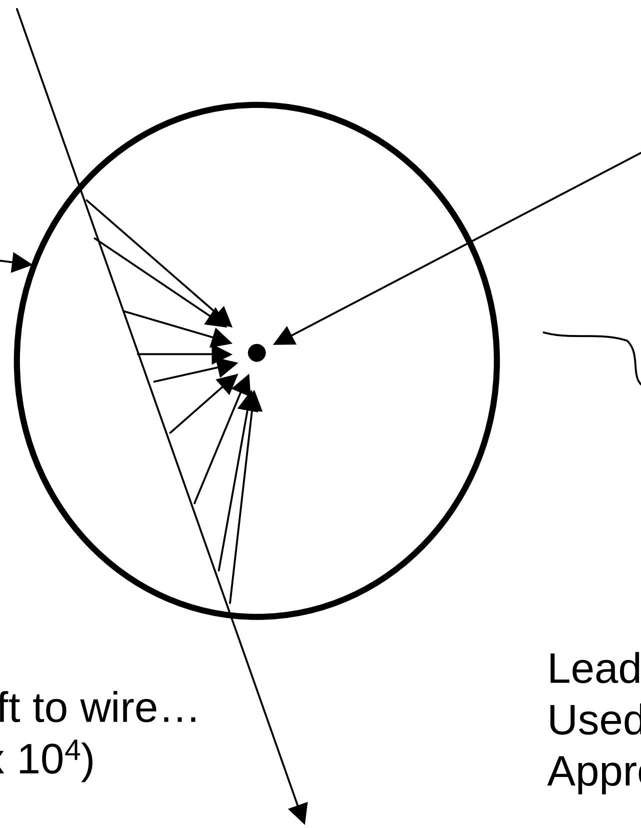
Each station contains 4 views
with 2 (offset by ½ diam) tubes per view.

We've performed some tests on a new improved plank. The stainless tubes are soldered in, the endplates are “tight” in an EMI sense, the tubes are terminated, our amplifying and discriminating electronics (which is a card using the 3 ASDQ's from the COT electronics at CDF) are shielded, and our readout is done using simple twisted flat.

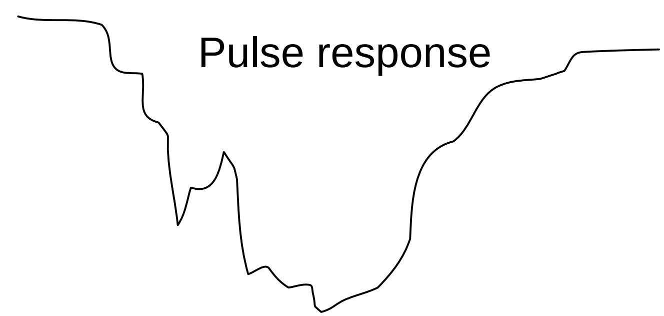
Cross Section of a Straw Tube



4mm diameter
Straw tube filled with
Gas (Inside of tube
is aluminized –
& has a protective
overcoat)



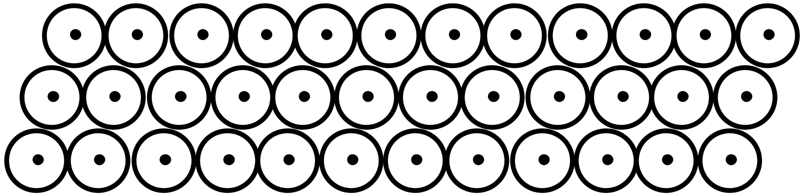
Small diameter
(20μ) gold-plated
Tungsten wire
Biased at +HV.



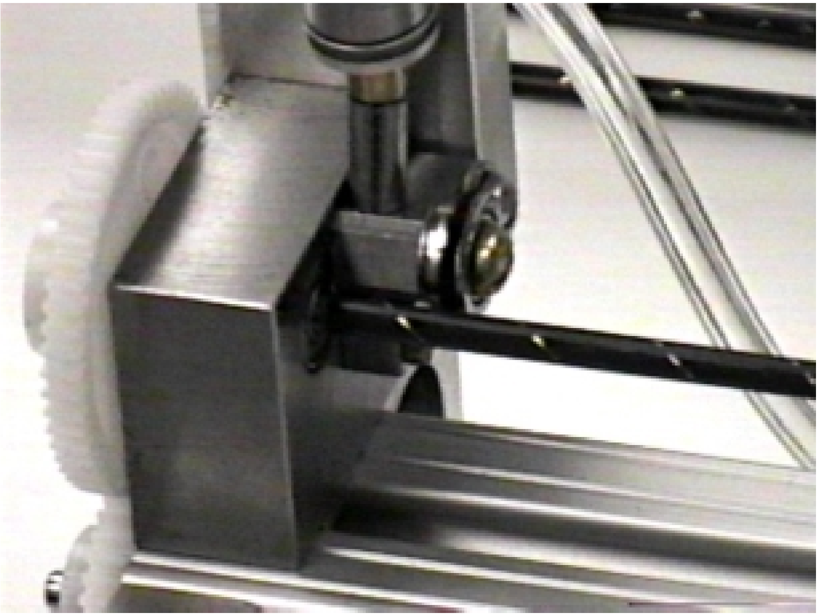
Charged particle leaves a
Trail of ionized gas; electrons drift to wire…
cause an avalanche (gain ~few x 10^4)

Leading edge timing can be
Used to infer distance of closest
Approach to sense wire (TDC)

Straw Chamber – Baseline Design



- Wire readout at both ends
  (glass bead at center)
- 3 layers per view
- 3 views per station
- >66000 straws in total



ATLAS TRT straw cutter

Straws:

Development effort recently reorganized.

Proposal calls for use of U.Penn. ASD, but does not specify which one. Choices include ASDQ, made for CDF COT in Maxim Cp, & ASDBLR, planned for ATLAS TRT – being prototyped in DMILL.

Requirement for TDC is “easy,” but no existing TDC can be read out fast enough for BTeV.

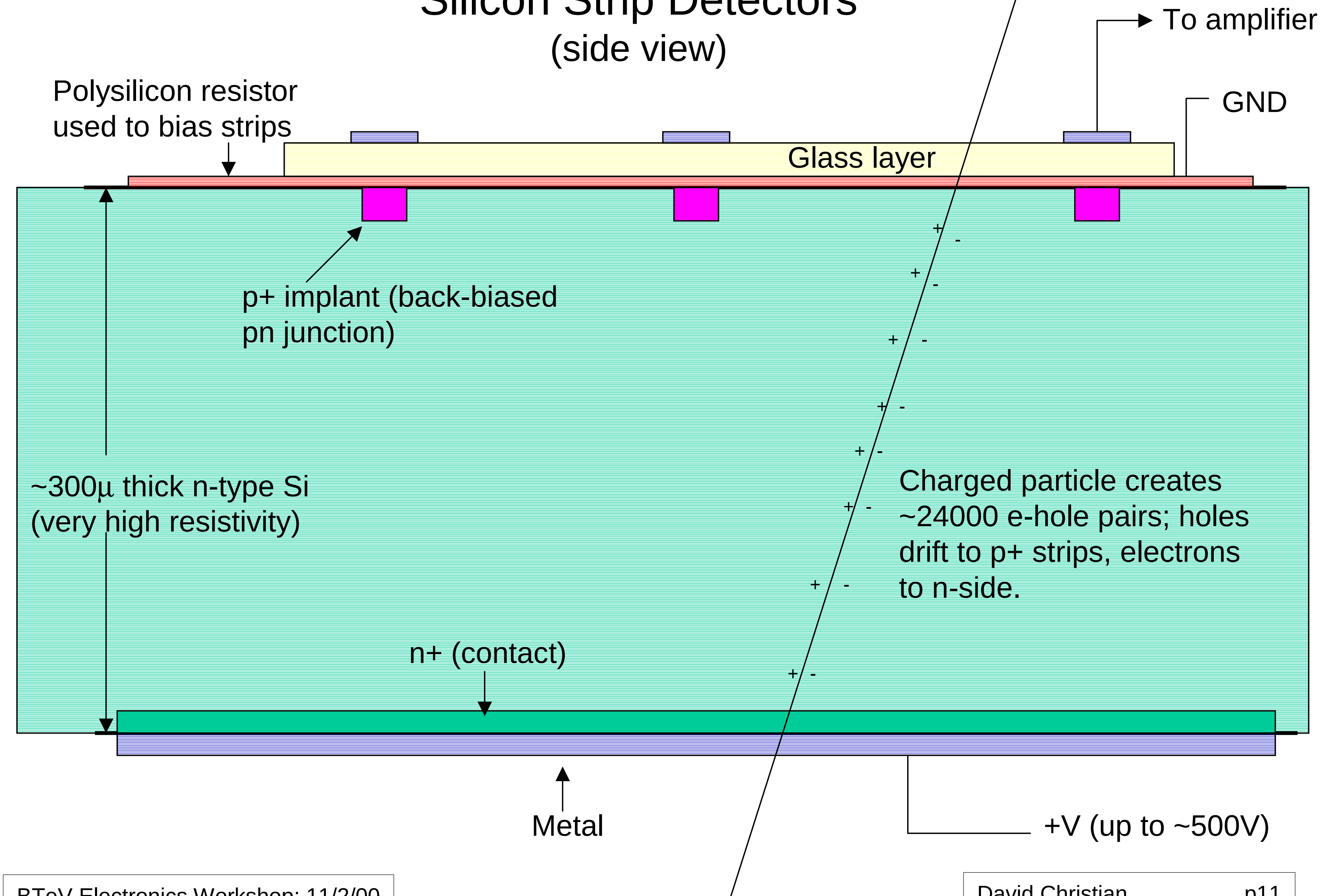
Silicon Strip Detectors

•Near the beam pipe, the density of tracks is too high for straws to handle (occupancy, radiation damage)

•Central 24 cm x 24 cm (OR MORE???) will be covered with SSD's (central hole for the beam pipe)

•100 μm pitch ➔ No problem with high occupancy (40x straw tube segmentation)

Silicon Strip Detectors
(side view)

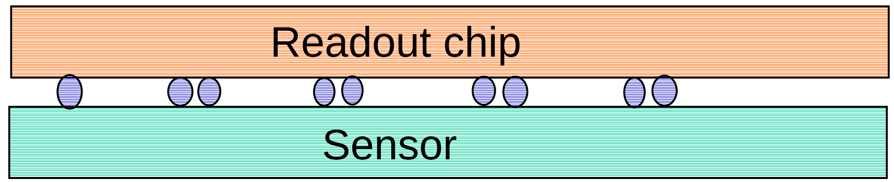


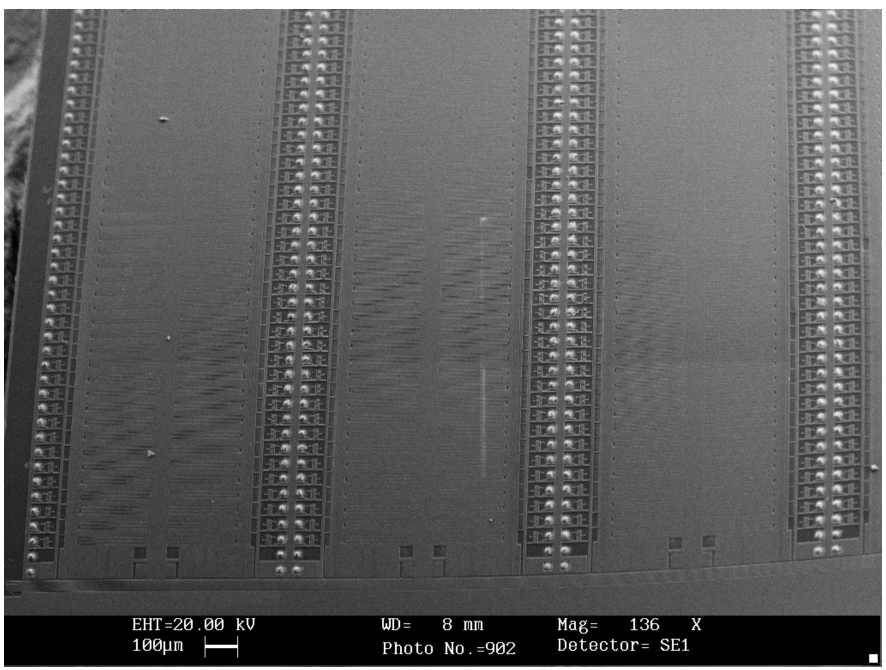
Silicon Strips:

Front end chip: to be designed & fabricated by Milano.
baseline = AC coupled single sided sensors
binary readout
as similar to pixel r/o chain as possible.

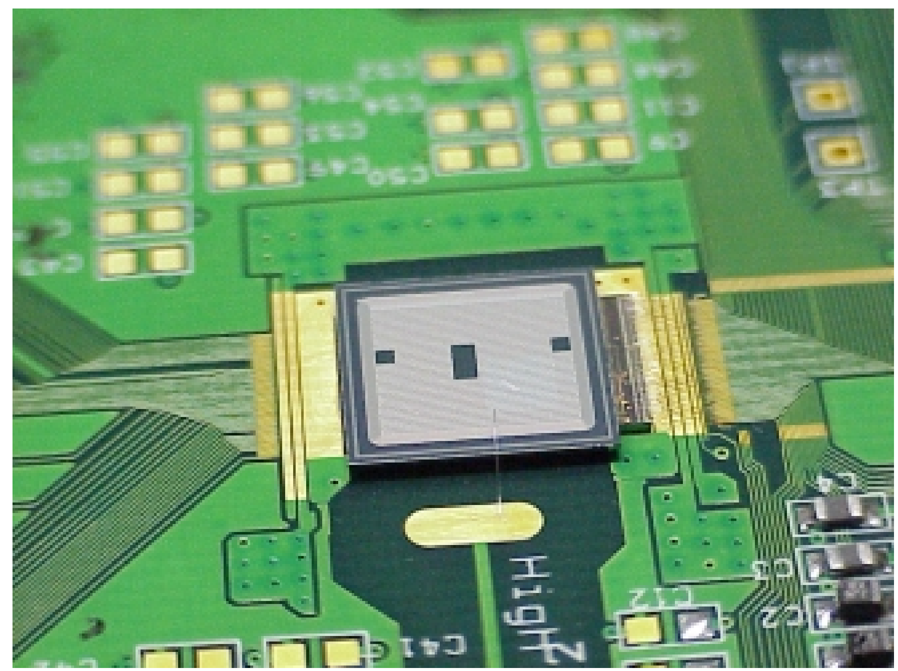
Hybrid pixel detectors

- Sensors & readout “bump bonded” to one another
- Principle of operation is similar to SSD’s – same signal (less noise)





FPIX1



FPIX1 bonded to ATLAS test sensor

FPIX2 Roadmap

- 0.25μ CMOS
  - (5 metal [6 possible], 2.5V)

- Design for 2 vendors ("lowest common denominator" design rules):
  - "CERN" – Very favorable contract, but problems with US Gov. restrictions
  - Taiwan Semiconductor Manufacturing Corp (TSMC) – Available through MOSIS

- <u>PreFPIX2-T (1999)</u> TSMC 0.25μ CMOS
  - New analog front end, with new leakage current compensation strategy
  - 8 comparators per cell (3-bit FADC); no EOC logic included
  - Array size = 2 x 160
  - Bench tests (radiation exposure)

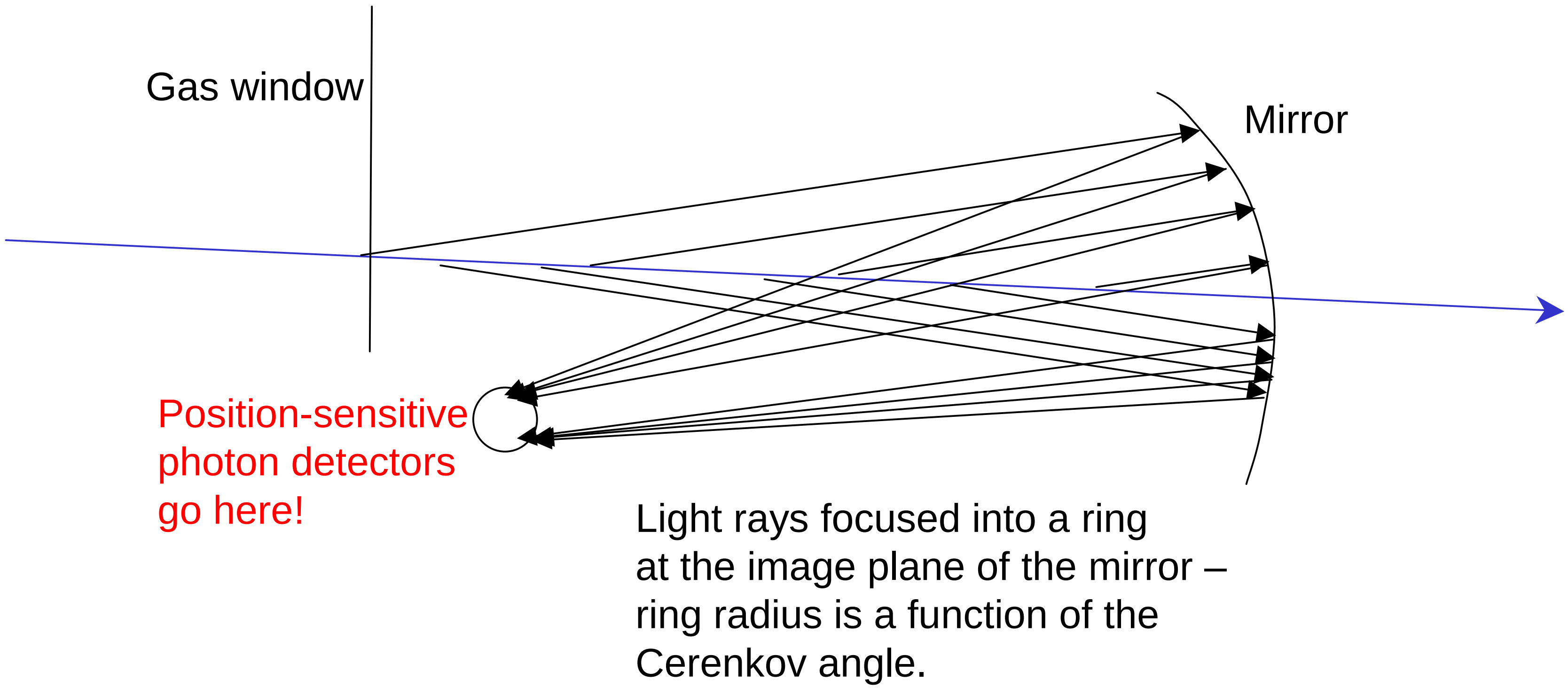
- <u>PreFPIX2-I (2000)</u> "CERN" 0.25μ CMOS
  - Same front end
  - Complete "core" – including new, simplified EOC & R/O (self-triggered only)
  - Array size = 18 x 32
  - Bench tests

- <u>PreFPIX2-T2 (2000)</u> TSMC 0.25μ CMOS (submitted; due back in early December)
  - New programming interface
  - Internal DAC's – no external currents required; only external voltages are 2.5V & ground.
  - Array size = 18 x 64

- <u>FPIX2 (2001)</u> 0.25μ CMOS - Final BTeV R/O chip!!??

RICH = Ring Imaging Cerenkov Counter

A charged particle traveling faster than the speed of light in a medium (e.g. a gas) emits light at a characteristic angle (an electromagnetic shock wave) --- This is Cerenkov light.



Baseline Cerenkov Photodetector = Hybid **P**hoto **D**iode:

vacuum device consisting of:

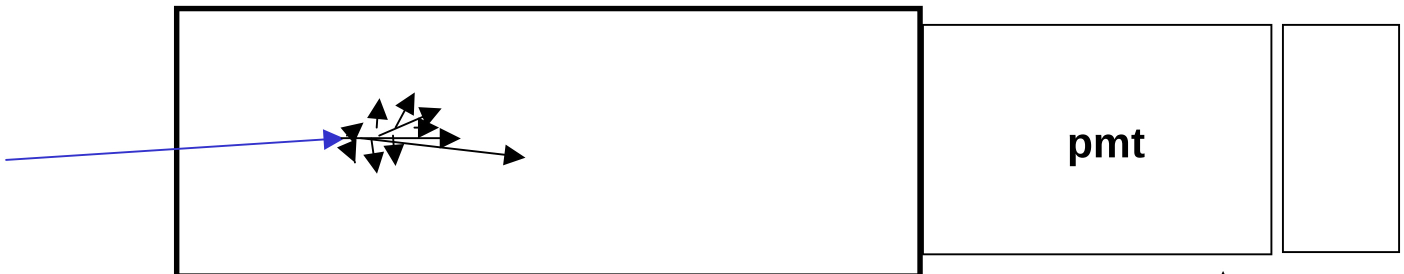
- photocathode on inside of vacuum window
- 20 KVolt accelerating potential
- silicon pad detector in vacuum
- signal = 1 $\gamma \rightarrow$ 1 e^- $\rightarrow$
  (20,000 eV/3.62 eV per e-h pair) – charge loss ≈ 5000 e^-

Baseline = DEP HPD w/163 channels per tube
(front end chips outside of vacuum).

The BTeV Electromagnetic Calorimeter

Lead tungstate crystal:

- **Very dense (showers don't spread – allows high segmentation)**
- **Radiation hard**
- **Fast scintillator**



Traditional (low gain) base (voltage divider)

Electromagnetic shower:

$\gamma \to e^+e^-$; $e^- N \to e^- \gamma N$; $\gamma e^- \to \gamma e^-$;…

Each electron deposits energy in the crystal, some Of which is transformed into scintillation light & Detected by the photo multiplier tube.

~10 pe's per MeV (incident) into a 2" pmt

EMCAL

~24K Lead-tungstate crystals coupled to PMT's
QIE's located outside of high rad area

Don't know where zero-suppression occurs.

Possible commonality:

- Pixels/SSD’s: Chip control, I/O specs
- Straws/Muon: ASD’s
- RICH/Muon: Latches, zero suppression method
- More???